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# SOUND RECORDING DEVICE, IN PARTICULAR FOR A PUBLIC ADDRESS SYSTEM

The invention relates to a sound recording device, in particular for a public address system according to the generic terms outlined in ~~claim 1~~ claim 16.

Sound recording devices in the form of individual microphones are known, which are available with or without directional characteristics. If sound recording devices are used in combination with public address systems at conference centers or speaker podiums, then it is desirable to have a high degree of feedback protection, good isolation from ambient noise, and a high degree of independence of the signal level from different speech directions and speaking positions.

Microphones without directional characteristics will tolerate differing speech directions and speaking positions, however they only offer minimal feedback protection and poor isolation from ambient noise. To compensate for these disadvantages, a smaller amplification scale has to be selected and at the same time much closer voice proximity maintained, so that the sound level of speech into the microphone is great enough to mask ambient noise. Changes in speech directions and speaking positions will cause comparatively larger variations in distance and also sound level fluctuations, compared to maintaining greater speech distance. Furthermore, unpleasant popping noises arise with plosives, created by air movement. In contrast, microphones with directional characteristics offer greater feedback protection and better isolation from ambient noise outside the sound recording range. The limited sound recording range, however results in sound level fluctuations due to deviations in speech direction and/or speaking position. Consequently, sound level

fluctuations due to deviations in speech direction and position are present with both types of microphone.

The invention is based on the exercise of improving a sound recording device, in particular for public address systems, so that not only a high degree of feedback protection and good isolation from ambient noise is achieved, but also a high degree of independence of the signal level from different speech directions and speaking positions, as well as protection from popping noises.

This exercise is resolved with a sound recording device, in particular for public address systems, according to the

generic terms of claim 1 displaying the characteristics indicated in this claim. Further developments and advantageous configurations of the invention can be taken from the clauses of the other claims, as well as the following description.

In the case of the sound recording device according to the invention, the transmitted sound from a sound source from at least two sound recorders is simultaneously recorded. By combining the received signals from all the sound recorders it is possible to record the sound, with even regular levels despite deviations in the propagation path or position of the sound source, as would be possible with just one single sound recorder.

At the same time, the summated amplitudes of the individual output signals of the sound recorder lead in total to an increase in level of sound signals, whose origin is the reference point, and this also leads to a reduction in level of ambient signals (on the transducer frame). Propagated from the reference point, the usable signals of the sound recorders are thereby matched, however noise signals and their noise impedance are unmatched. In this way the signal attenuation of the summated signals is improved by 3 dB with each doubling of the number of sound recorders. By appropriately selecting the number and configuration of sound recorders the position and size of the zone for effective sound recording - as well as noise impedance distance - can be selected. This results in correct operation of the whole sound recording device even when the individual sound recorders themselves do not display any directional characteristics.

The correct operation of the whole sound recording device distinguishes itself advantageously from the directivity of regular directional microphones, since the directivity does not diverge from the sound recorder to the sound source,

but converges at the reference point, similar to the focus of a concave mirror. In this way the desired feedback protection and isolation from ambient noise are both achieved, and compared to the potential directivity of individual sound recorders, is again improved. Furthermore greater distance between sound source and sound recorders is made possible, preventing popping sounds which can arise with plosives due to air movement. Besides this, the option exists to accommodate the sound recorder device in a compact casing at a greater distance from the speaker, so that forward view is not obstructed.

Also, deviations in the position of the sound sources are equalized within a restricted area about the reference point. In this way the previously feared volume fluctuation problems caused by movement of the speaker are effectively minimized.

In the simplest case the sound recorders are a consistent distance from the reference position and are arranged on a circular or spherical element, whose centrepoint is formed by the reference position.

This produces determinably consistent transmission times between the reference position and the sound recorders. In this way the signals of the sound recorders can be summated directly.

Transmission time elements can be determined by varying the distances between the reference position and the sound recorders.

Varying distances can be necessary due to design or structural constraints. However in order to maintain consistent transmission times, the various acoustic transmission times can be equalized by the transmission time elements so that the shorter transmission times from

the sound recorders, which are arranged closer to the reference position, can be artificially extended.

When using transmission time elements, individual or multiple sound recorders can be integrated together into sound transfer elements, whose transmission dimensions are adjustable to consistent signal levels of all sound recorders.

Since with closer proximity the sound level is higher than with greater distance, this effect is again equalized by the sound transfer elements and, in connection with the transmission time elements the desired greater distance can be precisely simulated. The term transmission dimension includes amplification, attenuation and unaltered amplitude of the signal.

Further, the sound recorders can display directional characteristics and be aligned so that the axes of their main receiving directions are pointed to the respective reference position.

In this way, the feedback protection and isolation from ambient noise are again improved. The restricted sound recording angle of individual sound recorders does not have disadvantages, as more sound recorders are available, whose sound recording ranges overlap, and therefore give an even sound sensitivity within the recording range of the sound recording device.

The sound recorders are preferably designed directly as acoustic-electric transducers.

This embodiment is particularly mechanically-constructively simple to achieve. Furthermore electric signals can, without loss in quality, be easily processed, in particular filtered, delayed, amplified or attenuated.

Alternatively the sound recorders can be shown as input valves of acoustic signal transmitter, which are fed to one or several grouped acoustic-electric transducers.

This alternative offers the option of also achieving acoustic transmission times and attenuations, so that for equalization the downstream electronic switching can be simpler in design.

Furthermore an optical marking facility for the set-point of the sound source can be incorporated.

This measure makes it easier for the speaker to find his/her optimum speaking positions and to maintain them.

The optical marking facility is advantageously created by having at least two light sources, each which emits a characteristic light beam from the sound recorder device in the direction of the set-point of the sound source within the respective range for the most favorable sound recording.

With this measure, automatic deviations from the optimum speaking position are signaled to the speaker, so that he/she can correct his/her position at any time.

A further development sees the configuration of the sound recorders and/or their main receiving direction and/or the transmission times of the transmission time elements being adjusted to changes in the ideal position of the sound source, so that the reference position of the sound recording device can follow the desired position of the sound source.

This measure facilitates more freedom of movement for the speaker, without compromising feedback protection and isolation from ambient noise, and a lesser requirement to

maintain a static, limited speaking position. Furthermore it can be adapted to speakers of different stature.

In so doing, the configuration of the sound recorders can be displaced and/or swiveled individually or grouped and a drive for displacing or swiveling them can be controlled either manually or by way of automatic position recognition of the sound source.

Further, the transmission times of the transmission time elements can be controlled either manually or by way of automatic position recognition of the sound source. The change in transmission times is also possible in combination with a change in the configuration of the sound recorders and/or their main receiving direction.

Suitable methods of position recognition can be based on the detection of thermal radiation from the face of the speaker, or radar, ultrasound or video picture processing.

According to a further development the activity and/or the position of the sound source can be determined by way of a correlator, which is fed signals from the sound recorders. Alternatively the position of the sound source can be calculated by measuring the time difference of the zero crossover of signals from the various sound recorders.

A correlator can determine the activity through the criteria of synchronous symmetrical or asymmetrical synchronously received signals at the sound recorders. This criteria indicates whether a sound source is at the reference position or in the vicinity of the reference position. The recognition of the activity can for example be used to connect through the sound recording device onto a public address system.

Furthermore the correlator can determine the position of the sound source by evaluating the phase displacements of the amplitude values received from the individual sound recorders, since these phase displacements are a measure of the distances of the sound source from the reference position.

In a preferred embodiment, the electric signals of the acoustic-electric transducers are, after digitalization, fed to a digital signal processor, which simulates the summation facility, transmission time elements, sound transfer elements and/or a correlator.

This facilitates very precise signal processing with high duplication accuracy. Special delay times can be achieved without losing quality, which can also be varied. Furthermore, transmission of several signal processing functions through the same signal processor are possible.

The sound recorders can also be designed as segments of a one-, two- or three-dimensional directionally deployed acoustic-electric transducer, whose surface is at least approximately, or in sections, of a circular or spherical element.

This embodiment depicts an alternative to the embodiment in which numerous individual acoustic-electric transducers are arranged directly next to one another on a circular or spherical element.

In the following, embodiment examples are explained with the assistance of diagrams.

The diagrams depict:

Fig 1 A schematic representation of the sound recording device according to the invention with acoustic-electric transducers on a circular element.

Fig 2 A configuration of the acoustic-electric transducers on a spherical element.

Fig 3 A sound recording device with acoustic-electric transducers in a particular straight-line area.

Fig 4 An optical facility for marking the optimum speaking position

Fig 5 A sound recording device with activity movement recognition.

Fig 6 A configuration for swiveling the sound recorders

Fig 7 A sound recording device with a facility for altering the main receiving direction.

Fig 8 A sound recording device with acoustic signal transmitters, and

Fig 9a, 9b Representations of one- and multi-dimensional acoustic-electric transducers.

Fig 1 shows a schematic representation of the sound recording device according to the invention with sound recorders 2 on a circular element 5. A reference position 1 corresponds to the ideal or desired position of a sound source. The sound recorders 2 are arranged so that directivity vectors 4 point in different directions between the reference position 1 and the sound recorders 2. The sound recorders 2, designed as direct acoustic-electric transducers, are in this case directional microphones, whose axes of their main receiving direction intersect at

the reference position 1. The amplitudes of the output signals of the individual sound recorders 2 are summated in a downstream summation facility 6 and transmitted along a conducting signal path 7. Due to the identical distances of all the sound recorders 2 from the reference position 1, the output signals are essentially synchronous or similarly amplified. When the output signals configuration of the sound source is at, or in, the proximity of the reference position 1, the output signals are summated to the maximum possible output signal strength.

When the sound source deviates laterally from the reference position 1, the output signal strength decreases with increased proportionality. In contrast, the output signal strength remains, to a large degree, independent of the position of the sound source, when this is an area between the reference position 1 and the sound recorders 2. This is explained in that the sound source approximates the individual sound recorders 2, at or adjacent to their axes of the main receiving direction 3 and whose signal level increases thereupon, whilst the sound source simultaneously emits from the main receiving direction 3 of other sound recorders 2, and whose signal level thereupon decreases. Through the addition of all the output signals, both these effects can be compensated to a large degree.

Whilst in Fig 1 the configuration of the sound recorders 2 is restricted to a circular element 5, Fig 2 depicts an embodiment in which the configuration of the sound recorders 2 also extends into the third dimension. Here the sound recorders 2 are arranged on a spherical element 5. With this configuration an improved concentration of the reception at the reference position 1 is again achieved, as height deviations are also considered.

Fig 3 shows sound recording device with sound recorders 2 in a straight line. Here, the sound recorders 2 are

arranged at various distances from the reference position 1, namely the intersection of the main receiving direction 3 of the sound recorders 2. This configuration leads to a more compact configuration of the speaker podium. It is clear that the transmission time of the sound from the reference position 1 to the sound recorders 2 is different according to the various distances. The recording volume of the sound recorders 2 further away is likewise less. These differences are equalized here by transmission times elements 8 and sound transfer elements 18 switched downstream, which are assigned to the sound recorders 2 placed closer to the reference position 1. The transmission dimensions of the sound transfer elements 18 are comparable to an attenuation. By using the transmission time elements 8 and sound transfer elements 18 the middle four sound recorders 2 can be arranged virtually, as if they were the same distance from the reference position 1 as the outer sound recorders 2.

Fig 4 shows an optical facility for marking the optimum speaking position. This device consists of two light sources 9, each of which emits light into a restricted predetermined zone. The predetermined zones are designed so the zones of the light distribution overlap and the reference position 1 lies in the center of these overlapping zones. Only in these intersecting zones 10 does the speaker see both light sources 9, which signals to him, that he is situated in an effective sound recording zone. If he sees only one light source 9, then he is outside of the effective sound recording zone and can thus correct his position.

Fig 5 shows a sound recording device with activity recognition. In this case, the outputs of all sound recorders 2 are connected to a correlator 11. One output of the correlator 11 is connected via a threshold value detector 12 with a control input of a switch 13 at the

switching output of the summation facility 6. The correlator 11 checks the output signals of the sound recorders 2 for coordination of their amplitudes and phases. Only if a sound source is placed at the reference position 1 do all amplitudes and phases correspond, which indicate a high correlation factor. With increased distance of the sound source from the reference position 1, the individual or multiple amplitude- and phase-values deviate more and more from the others, which minimizes the correlation factor.

The absolute value of the amplitude stays within wide parameters without any significant influence on the correlation factor established. In this way it can be automatically recognized as to whether a sound source is in the proximity of the reference position 1 or not. The correlation factor offers very reliable and fault-free criteria for the mobility of a sound source at or in the proximity of the reference position 1. The output signal of the correlator 11 can via the threshold value detector 12 and the control input of the switch 13, be used to automatically connect through microphone signals at conference centers.

Fig 6 shows a configuration for swiveling the sound recorder 2. The sound recorder 2 is permanently affixed onto a mount 19, which can also be swiveled. A drive element 16 in the form of a pressure cylinder is coupled to the mount 19, so that the mount 19 can be swiveled. In order to adjust the sound recorders 2, control buttons can be used, which are attached to a control device 15. If at the same time an optical facility for marking the optimum speaker position is incorporated, then adjustment of the facility by the user is made considerably easier.

Instead of manual adjustment, the adjustment can also be performed automatically. In this case, the position of the

face or body of the speaker is determined by a position recognition device 14, by means of a known method, such as automatic evaluation of thermal radiation from the face; evaluation of radar or ultrasound sensors; or evaluation of video pictures. With the help of this information controls the drive element 16 is controlled via the control device 15 in such a way that the altered reference position 1' comes as close as possible to the established position of the head.

Fig 7 shows a sound recording device with a device for changing the main receiving direction 3. The sound recorders 2 are once again directional microphones. These have the special feature in that their main receiving direction 3 can be altered by electric control signals. For this, various solutions are known, for example by superimposing the signals of two sound recorders 2 installed close together.

The sound recorders 2 are affixed on a straight line. For the transmission times and amplitude equalization, corresponding transmission time elements 8, and sound transfer elements 18 are connected downstream of each sound recorder 2. The delay times of the transmission time elements 8 as well as the transmission dimensions of the sound transfer elements 18 are continuously adjustable via a control device 15. The output signals of the sound recorders 2 are fed to a correlator 11 which calculates the transmission delay variances of the sound with the sound recorders 2. The position of the sound source can be determined from these transmission time variances. Furthermore the control device 15 sends commands for adjusting the main receiving direction 3 for each of the sound recorders 2, without having to involve mechanical movements; also commands for adjusting the transmission time elements 8 and sound transfer elements 18, in order to correct the transmission delay variances and amplitude

variances. In this case as well an altered reference position 1′ arises. On account of the position information of the sound source at hand the control device 15 can additionally decide as to whether the sound source lies within the desired range, and can undertake to switch to the conducting signal path.

The depicted switching configuration can be altered in such a way, so that the correlator 11 can be connected behind the transmission time elements 8 and sound transfer elements 18. Further, it is possible to design the correlator 11, transmission time elements 8 and the sound transfer elements 18 as digital signal processors, i.e. all evaluations and adjustments are performed by software.

Fig 8 shows a sound recording device with acoustic signal transmitters 17, which are fed to a single acoustic-electric transducer. In this way it is possible to reduce the number of acoustic-electric transducers, and likewise the costs thereof. In this, in places where previously acoustic-electric transducers were applied, acoustic signal transmitters 17 instead of the sound valves can be used. The sound valves can be attached in such a way, so that for the sound reception, a respective salient pole directivity is derived, which for example are known from directional tubes used as microphones, which work along the interference principle. The induction conductors 17, which are generally simple tubes, are all fed grouped to one single acoustic-electric transducer. The lengths of the acoustic signal transmitter 17 can be carefully selected so that the transmission time of the sound from the reference position 1 to the acoustic-electric transducer is the same as through all acoustic signal transmitters 17.

Fig 9a shows the representation of a one-dimensional and in Fig 9b a representation of a two or three dimensional elongated acoustic-electric transducer. According to Fig 9

the surface is at least approximate, or in sections, of a circular or spherical element. This configuration is equal to a large number of acoustic-electric transducers, which are directly adjacent to one another. Even if the transducer is designed with a mechanically penetrating membrane, the individual elements work as a single acoustic-electric transducer whose signals here are integrally summated. Here also, directivity such as that with individual transducers is achieved.